# Risk factors of diastasis recti abdominis, and relationship with surface electromyography characteristics of pelvic floor muscles in early postpartum: a retrospective study (#113305)



First submission

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# Risk factors of diastasis recti abdominis, and relationship with surface electromyography characteristics of pelvic floor muscles in early postpartum: a retrospective study

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Objective : This study aimed to identify the risk factors for diastasis recti abdominis ( DRA ) in early postpartum women and investigate any relationship with surface electromyography ( sEMG ) characteristics of pelvic floor muscles ( PFM ) .

Methods: A total of 478 participants who visited Fujian Maternity and Child Health Hospital for postpartum re-examination between January and March 2023 were divided into two groups: DRA and Non-DRA. Basic demographic data were collected via self-reported questionnaires. Additionally, inter-recti distance ( IRD ) was measured using ultrasound imaging, and pelvic floor muscles activity was assessed using surface electromyography according to the Glazer protocols.

Results: There were no significant differences between the Non-DRA and DRA groups in terms of weight gain during pregnancy, physical activity, number of fetuses, delivery mode, gestational diabetes, or urinary incontinence during pregnancy or postpartum. However, the DRA group was older and had a significantly higher level of education. Both pre-pregnancy and postpartum body mass index ( BMI ) were higher in the DRA group. The proportion of first-time mothers was greater in the Non-DRA group, and fetal weight was lower in the Non-DRA group compared to the DRA group. No significant differences were observed in sEMG parameters between the two groups at the pre-baseline, flick contraction, tonic contraction, endurance contraction, and post-baseline stages.

Conclusion: Age, education level, number of deliveries, pre-pregnancy BMI, postpartum BMI, and fetal weight were identified as risk factors for diastasis recti abdominis in early postpartum. No correlation was found between the sEMG characteristics of pelvic floor muscles and diastasis recti abdominis in the early postpartum period.

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## Introduction

Diastasis recti abdominis （DRA） is defined as the separation of the two rectus abdominis muscles by more than 2 cm, caused by thinning and widening of the linea alba (Hernández-Granados et al., 2021). This condition is common in women during pregnancy as the abdomen expands to accommodate the growing fetus. Studies have shown that the prevalence of DRA ranges from 27% to 100% during the second and third trimesters of pregnancy, and from 30% to 68% in the postpartum period (Boissonnault & Blaschak, 1988; Fernandes et al., 2015a). As a key component of the abdominal core, the rectus abdominis plays a vital role in maintaining posture, stabilizing the trunk and pelvis, facilitating respiration, and supporting abdominal organs. The pelvic floor muscles （PFM）, which are often compromised during the postpartum period, have garnered significant attention among healthcare professionals, physical therapists, and patients. The pelvic floor consists of multiple layers of muscles, including the levator ani group and the coccygeus muscle, forming a supportive sling at the base of the pelvis (Corton, 2009). These muscles are essential for supporting pelvic organs and regulating bodily functions such as urination, defecation, and sexual activity. Pelvic floor dysfunction （PFD） encompasses a variety of symptoms, including urinary and fecal incontinence, pelvic organ prolapse, and sexual dysfunction (Rogers et al., 2018). Importantly, the pelvic floor muscles do not function in isolation; rather, they work in synergy with the abdominal muscles and the thoracic diaphragm to modulate intra-abdominal pressure (Hodges et al., 2007; Sapsford et al., 2001a).

The relationship between abdominal muscles and pelvic floor function remains a topic of ongoing debate. Some studies suggest that the transversus abdominis and obliquus internus muscles are recruited during pelvic floor muscle contractions, indicating a significant influence of abdominal muscles on pelvic floor performance (Neumann & Gill, 2002). This has led to the hypothesis that strengthening the abdominal muscles may concurrently enhance pelvic floor function due to their co-contraction (Bø, 2004). Additionally, research has shown that middle-aged women with DRA are more likely to experience stress urinary incontinence, fecal incontinence, and pelvic organ prolapse compared to women without DRA (Spitznagle et al., 2007a). However, other studies argue that there is no clear relationship between diastasis recti abdominis and pelvic floor dysfunction. Despite the anatomical and functional interactions between the PFM and abdominal muscles, some evidence suggests that women with DRA do not exhibit significant pelvic floor muscle weakness or higher rates of urinary incontinence or pelvic organ prolapse (Bø et al., 2017a; Wang et al., 2020a; Fei et al., 2021a). These conflicting findings highlight the complexity of the relationship between DRA and pelvic floor function.

In summary, existing studies present inconsistent conclusions regarding the association between DRA and pelvic floor dysfunction. This highlights the need for careful consideration of the sequence and approach to rehabilitating the rectus abdominis and pelvic floor muscles during the postpartum period. This study aimed to compare the sEMG characteristics of the PFM, including vaginal resting pressure, muscle strength, and endurance, between women with and without DRA in early postpartum. Additionally, we sought to explore the prevalence of urinary incontinence（UI）in both groups. We hope this study will provide a theoretical foundation for the postpartum rehabilitation for women with PFD and DRA.

## Materials & Methods

### Participants

The retrospective study included 478 participants who visited Fujian Maternity and Child Health Hospital for postpartum re-examination between January and March 2023. The inclusion criteria: women between 6 weeks and 2 months postpartum, who underwent PFM sEMG and rectus abdominis distance measurement, and who had not received any prior pelvic floor or rectus abdominis therapy. Exclusion criteria included a history of pelvic surgery, neurological diseases, trunk deformities, or incomplete personal information. The study was granted an informed consent waiver by the Ethics Committee of Fujian Maternity and Child Health Hospita （No.2024KY219）.

### Measure the rectus abdominis distance

The inter-rectus distance (IRD), defined as the width of the linea alba, was measured using ultrasound imaging （PoLinGer, Anhui, China）. Measurements were taken at five points along the abdominal midline of the linea alba: 4.5 cm and 3 cm above the umbilicus, 4.5 cm and 2 cm below the umbilicus, and at the upper margin of the umbilical ring (Beer et al., 2009a; Chiarello & McAuley, 2013). Participants were positioned supine with both knees bent at 90°. The examination points were marked on the skin while the participants were at rest. To assess rectus abdominis contraction, participants were instructed to cross their hands behind their heads, slowly lift their head and shoulders off the bed while exhaling, and raise their shoulder blades to a 40° angle relative to the bed. This position was maintained for 3 seconds to ensure proper rectus abdominis contraction. Diastasis recti abdominis was classified quantitatively as a linea alba width exceeding 2 cm (Mota et al., 2012).

**Access pelvic floor surface EMG**

Before the evaluation, participants were instructed to empty their bladders and adopt a 120° semi-supine position with knees bent and hips outwardly rotated. Intrapelvic surface electromyography, a non-invasive method for assessing pelvic floor muscle activity, was performed using a human biostimulation feedback instrument （MLD B2T, Medlander, Najing, Jiangsu, China） following the Glazer protocol (Glazer & Hacad, 2012).

The Glazer protocol consisted of the following five phases:

Pre-baseline Rest (60 seconds): Participants were instructed to relax completely, and recorded the electromyographic activity of the pelvic floor muscles in a resting state.

Phasic (Flick) Contractions (5 repetitions): Participants were asked to rapidly contract and immediately relax their pelvic floor muscles, repeated five times (2-second contraction with a 2-second rest between contractions).

Tonic Contractions (5 repetitions): Participants performed five sustained contractions, holding each contraction for 10 seconds followed by a 10-second rest period.

Endurance Contraction (60 seconds): Participants were instructed to contract their pelvic floor muscles to a specific level and maintain the contraction for 60 seconds.

Post-baseline Rest (60 seconds): Participants were again instructed to relax completely, and the post-assessment electromyographic activity of the pelvic floor muscles was recorded.

**Statistical analysis**

Statistical analyses were conducted using SPSS software version 25.0（IBM Corporation, Armonk, NY, USA）. Continuous variables were presented as means ± standard deviations if normally distributed, or as medians with interquartile ranges if skewed. Normality was assessed using the Kolmogorov-Smirnov test. For normally distributed data, inter-group comparisons were performed using Student's t-test, while non-normally distributed data were analyzed using the Mann-Whitney U test. Categorical variables were expressed as frequencies and percentages, and comparisons were made using the Chi-square test or Fisher's exact test. A two-tailed p value $< 0.05$ was considered statistically significant.

## Results

The study included 478 postpartum women, with a mean age of 30.52 years. Among the participants, 301（62.97%）were primiparous, and 177（37.03%）were multiparous. In terms of delivery mode, 337（70.5%）had vaginal deliveries, while 141（29.5%）underwent cesarean sections. Diastasis recti abdominis was identified in 347 patients（72.6%）, whereas 131（27.4%）had normal rectus abdominis morphology.

There were no statistically significant differences between the Non-DRA and DRA groups in terms of weight gain during pregnancy, physical activity, number of fetuses, delivery mode, gestational diabetes, urinary incontinence during pregnancy, or postpartum urinary incontinence.

However, the DRA group was older than the Non-DRA group（$p < 0.01$）. Additionally, the DRA group also had a significantly higher level of education, with a greater proportion having higher education compared to the Non-DRA group（$p < 0.01$）. Both pre-pregnancy （$p=0.016$）and postpartum BMI （$p=0.011$） were higher in the DRA group. The proportion of primiparous women was higher in the Non-DRA group （$p=0.03$）, while fetal weight was lower in the Non-DRA group compared to the DRA group （Table 1）.

The sEMG using the Glazer protocol was employed to assess the recruitment levels of neuromuscular motor units, reflecting the functional status of the pelvic floor muscles, including muscle strength, reactivity, and endurance. There were no statistically significant differences in sEMG parameters between the two groups during the pre-baseline, flick contraction, tonic contraction, endurance contraction, or post-baseline phases（$p > 0.05$）（Table 2）.

## Discussion

The present study revealed a 72.6% prevalence of rectus abdominis dissociation at 6 weeks postpartum, which is notably higher than the 60% reported in previous research (Sperstad et al., 2016a). This discrepancy may be attributed to methodological differences in measurement protocols. Unlike prior studies that exclusively measured positions 4.5 cm above and below the umbilicus, our investigation incorporated additional measurement points at 3 cm above and 2 cm below the umbilicus. This modification was informed by previous findings indicating that the maximal separation of rectus abdominis in nulliparous women typically occurs at these locations (Beer et al., 2009b). Furthermore, our study defined DRA as a separation distance exceeding 2 cm at any point, contrasting with the conventional criterion of greater than two fingerbreadths (approximately 3 cm) employed in other studies.

The risk factors of DRA are also controversial. Our analysis identified age, education level, pre-pregnancy BMI, number of deliveries, and baby birth weight as significant risk factors. However, these findings contradict previous research that found no association between DRA and pre-pregnancy BMI, weight gain, and baby birth weight (Fernandes et al., 2015b). These inconsistencies may stem from variations in the timing of DRA assessment across studies, given the dynamic nature of DRA prevalence throughout the postpartum period. The global prevalence of DRA has been reported as 70% in the third trimester, 60% at 6 weeks postpartum, and over 30% at 1 year postpartum (Sperstad et al., 2016b). Recent investigations have further elucidated these temporal patterns. Fei et al. identified cesarean delivery and multiple gestation as risk factors for DRA within one year postpartum, using an inter-recti distance (IRD) of $\geqslant 2$ cm as the diagnostic threshold (Fei et al., 2021b). Lina Wu et al. Wu et al. (2021) demonstrated age-stratified risk factors, with parity and diabetes mellitus emerging as significant predictors in younger women, while obesity and diabetes were predominant in older populations. (Wu et al., 2021). A longitudinal study by Lin et al. revealed temporal variations in risk factors, with BMI emerging as significant at 10 years postpartum, parity at 3, 5, and 10 years postpartum, multiple gestation at 3 years postpartum, and diabetes mellitus at 20 and 30 years postpartum. (Lin et al., 2024). These findings underscore the importance of considering temporal and demographic factors in DRA risk assessment, which is crucial for developing targeted prevention and management strategies. Furthermore, the establishment of standardized diagnostic criteria is imperative to prevent clinical overdiagnosis and unnecessary interventions.

The utility of sEMG in assessing pelvic floor muscle bioelectrical activity and co-activation patterns has been well-established (Tahan et al., 2013; Chmielewska et al., 2015). Our comparative analysis of PFM sEMG parameters between DRA and non-DRA groups in the early postpartum period revealed no significant differences in PFM strength or endurance. These findings align with previous research, though it should be noted that our methodology employed ultrasound for DRA detection, which offers greater precision than the fingerbreadth measurement used in earlier studies (Wang et al., 2020b). Zhang et al. found that the endurance of vaginal sphincter and external anal sphincter in DRA group was weakened compared with Non-DRA group, and the sEMG of other pelvic floor muscles showed no difference between the two groups (Zhang et al., 2023). This discrepancy may be attributable to methodological differences, as our study assessed global PFM activity, whereas Zhang et al. evaluated individual PFM components.

The theory of pelvi-abdominal dynamics suggests that the abdominal and pelvic floor muscles have a synergistic effect (Sapsford et al., 2001b). During PFM contraction, coordinated abdominal muscle activation facilitates effective pelvic floor contraction (Serrano et al., 2018). Impairment of abdominal musculature may compromise this synergistic mechanism, potentially exacerbating pelvic floor dysfunction. Ptaszkowsk et al. found that in menopausal women with stress urinary incontinence （SUI）, when the pelvic floor muscle contracted alone, the rectus abdominis muscle contracted synergically (Ptaszkowski et al., 2015). Recent therapeutic approaches have incorporated this understanding, with EMG-biofeedback- assisted pelvic floor muscle training combined with rectus neuromuscular electrical stimulation （NMES） was more effective than the treatment of rectus NMES alone (Liang et al., 2022). However, concerns have been raised regarding potential adverse effects of PFM and transverse abdominis contractions on DRA in postpartum women, highlighting the need for further investigation into optimal timing and modalities of postpartum rehabilitation (Theodorsen et al., 2019).

In terms of the relationship between DRA and SUI, Bo et al. (Bø et al., 2017b), Braga et al. (Braga et al., 2019), Liu et al. (Liu et al., 2023)reported that postpartum DRA of first-time mothers had nothing to do with SUI, while a study by Spitznagle et al. of the prevalence of DRA in the elderly urogynecological population concluded that patients with DRA were more likely to have fecal incontinence, pelvic organ prolapse, and stress incontinence than patients without DRA(Spitznagle et al., 2007b). Our findings align with the former studies, showing no association between DRA and SUI during pregnancy or early postpartum. This discrepancy may reflect population differences, as Spitznagle et al.'s cohort had a median age of 52.45 years, compared to our postpartum sample. Interestingly, Devreese et al. published a study in which they found that the order of muscle contraction in the superficial and deep pelvic floor muscles was consistent in women without urinary incontinence, while the order of muscle contraction was different in women with urinary incontinence (Devreese et al., 2007). In the future, the EMG collection of pelvic floor muscle should be more refined. This study was mainly to analyze the relationship between rectus abdominis muscle separation and stress incontinence, and further study could explore the relationship and specific mechanism between rectus abdominis muscle and pelvic floor muscles in stress incontinence by detecting bioelectrical signals. At the same time, considering the synergistic effect of rectus abdominis and pelvic floor muscles, the method should be optimized to reduce the interaction between muscles in the future myoelectric assessment of pelvic floor muscles.

Several limitations should be acknowledged in this study. The retrospective design and reliance on self-reported measures for certain parameters such as physical activity and urinary incontinence may introduce recall bias. Additionally, the variability of PFM activity in the early postpartum period may have limited our ability to detect significant effects, suggesting that assessments at later time points may yield different results. Future prospective studies with standardized assessment protocols and longer follow-up periods are warranted to further elucidate the complex relationships between DRA, PFM function, and pelvic floor disorders.

## Conclusions

In conclusion, this study identified several significant risk factors for diastasis recti abdominis in the early postpartum period, including maternal age, educational attainment, parity, pre-pregnancy BMI, postpartum BMI, and fetal weight. The analysis of pelvic floor muscle function through surface electromyography revealed no significant correlation between PFM characteristics and the presence of DRA during this period. These findings suggest that the clinical management of postpartum DRA should prioritize targeted abdominal and core rehabilitation strategies rather than focusing exclusively on PFM strengthening exercises. This approach aligns with the current understanding of abdominal-pelvic dynamics and may provide more effective outcomes in the treatment and prevention of postpartum DRA.

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## Table 1(on next page)

Demographic and clinical characteristics

**Table 1 Demographic and clinical characteristics**

| Characteristics | Non-DRA group | DRA group | t/Z/$x^2$ | *p*-Value |
|---|---|---|---|---|
| **Age（years）** | 29.09±4.58 | 31.06±3.69 | -4.69 | ＜0.01[2] |
| **Education** | | | 23.08 | ＜0.01[3] |
| College/university | 35(26.7%) | 68(14.2%) | | |
| Primary/high school/other | 96(73.3%) | 410(85.8%) | | |
| **Pre-pregnancy BMI（$kg/m^2$）** | 21.16±2.90 | 21.75±3.26 | -2.4 | 0.016[2] |
| **Weight gain during pregnancy（kg）** | 23.37±2.95 | 24.14±2.91 | -0.39 | 0.695[2] |
| **Postpartum BMI（$kg/m^2$）** | 23.37±2.95 | 24.14±2.91 | 0.24 | 0.011[1] |
| **Physical activity≥1 time per week** | 29(22.1%) | 68(19.6%) | 0.38 | 0.538[3] |
| **Number of deliveries** | | | 21.93 | ＜0.01[3] |
| 1 | 104(79.4%) | 197（56.8%) | | |
| 2 | 26（19.8%) | 132(38%) | | |
| 3 | 1（0.8%) | 18(5.2%) | | |
| **Number of fetuses** | | | | 0.565[4] |
| 1 | 131（100%) | 344（99.1%) | | |
| 2 | 0 | 3（0.9%) | | |
| **Delivery mode** | | | 2.04 | 0.153[3] |
| Vaginal delivery | 86（65.6%) | 251（72.3%) | | |
| Forceps delivery | 45（34.4%) | 96（27.7%) | | |
| **Fetal weight（kg）** | 3.13±0.56 | 3.25±0.48 | -2.17 | 0.030[2] |
| **GDM** | 20（15.3%) | 56（16.1%) | 0.05 | 0.816[3] |
| **Urinary incontinence during pregnancy** | 40(30.5%) | 112(32.3%) | 0.13 | 0.715[3] |
| **Postpartum urinary incontinence** | 25（19.15%) | 65（18.7%) | 0.008 | 0.930[3] |

BMI- body mass index，GDM- gestational diabetes mellitus

[1]Student's t-test

[2]Mann-Whitney U test

[3]Chi-square test

[4]Fisher's exact test

*p* value < 0.05 was considered statistically significant.

## Table 2(on next page)

Comparison of the surface electromyography parameters of pelvic floor muscles between Non-DRA and DRA group

**Table 2 Comparison of the surface electromyography parameters of pelvic floor muscles between Non-DRA and DRA group**

| **Parameters** | **Non-DRA group** | **DRA group** | **t/Z/F** | ***p*-Value** |
|---|---|---|---|---|
| | | | | |
| **Pre-baseline** | | | | |
| mean value(uV) | 5.56±3.41 | 6.22±3.82 | -1.697 | 0.090[2] |
| **Flick contraction** | | | | |
| maximum value(uV) | 39.44±17.94 | 39.98±17.94 | 0.007 | 0.769[1] |
| **Tonic contraction** | | | | |
| mean value(uV) | 27.79±14.97 | 27.82±14.36 | -2.43 | 0.808[2] |
| maximum value(uV) | 45.62±22.29 | 45.99±22.18 | -0.31 | 0.757[2] |
| variability | 0.25±0.15 | 0.24±0.09 | -0.1 | 0.320[2] |
| **Endurance contraction** | | | | |
| mean value(uV) | 23.36±12.94 | 23.96±12.59 | -0.57 | 0.571[2] |
| variability | 0.24±0.16 | 0.23±0.09 | -1.24 | 0.216[2] |
| **Post-baseline** | | | | |
| mean value(uV) | 4.69±3.40 | 5.40±3.96 | -1.62 | 0.105[2] |

[1]Student's t-test

[2]Mann-Whitney U test

[3]Chi-square test

[4]Fisher's exact test

*p* value < 0.05 was considered statistically significant.